# 6. Assessment of the Arrowtooth Flounder stock in the Eastern Bering Sea and Aleutian Islands

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## Executive Summary

The scheduled frequency for some stock assessments was recently changed in response to the National Stock Assessment Prioritization effort (Methot 2015; Hollowed et al. 2016). In previous years, all Bering Sea and Aleutian Island (BSAI) flatfish stocks were assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. There was no change in this schedule for the Arrowtooth flounder stock. For this off-cycle (odd) year, we present a partial assessment consisting of an executive summary with recent fishery catch and survey trends as well as recommend harvest levels for the next two years. In on-cycle (even) years, we will present a full stock assessment document with updated assessment and projection model results to recommend harvest levels for the next two years. Please refer to last year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Shotwell et al., 2020, available online at (https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/BSAIatf.pdf).

We use a statistical age-structured model as the primary assessment tool for the BSAI Arrowtooth flounder (ATF, *Atheresthes stomias*) stock which qualifies as a Tier 3 stock. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels. The data sets used in this assessment include total catch biomass, fishery size compositions, bottom trawl surveys abundance estimates (eastern Bering Sea (EBS) shelf, EBS slope, and Aleutian Islands), bottom trawl survey age compositions, and bottom trawl survey size compositions when age compositions are not available. For an off-cycle year, we do not re-run the assessment model, but do update the projection model with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points. We continue to use the 2018 assessment model (18.9). Please see Spies et al., (2018) for more details on the 2018 assessment methodology (available online at: https://apps-afsc.fisheries.noaa.gov/REFM/Docs/2018/BSAI/BSAIatf.pdf).

### Summary of Changes in Assessment Inputs

*Changes in the input data:*

There were no changes made to the assessment model inputs since this was an off-cycle year. New data added to the projection model included an updated 2020 catch estimate of 10,681 t and new catch estimates for 2021-2023. We estimated the 2021 catch by increasing the official catch as of October 30, 2021, by an expansion factor of 1.07, which represents the average fraction of catch taken after October 30th in the last five complete years (2016-2020). This resulted in an estimated catch for 2021 of 8,698 t. To estimate future catches, we updated the yield ratio to 0.13, which was the average of the ratio of catch to ABC for the last five complete catch years (2016-2020). This yield ratio was multiplied by the projected ABCs from the updated projection model to generate catch estimates of 9,272 t in 2022 and 8,806 t in 2023.

*Changes in the assessment methodology:*

There were no changes to the assessment methodology since this was an off-cycle year.

## Summary of Results

Based on the projection model results, recommended ABCs for 2022 and 2023 are 80,389 t and 83,389 t, respectively, and the OFLs are 94,445 t and 97,944 t. The new ABC and OFL recommendations for 2022 are similar to the 2021 ABCs and OFL developed using the 2020 full assessment model. The stock is not overfished, and is not approaching a condition of being overfished. Reference values are presented in the following table.

| | As estimated or *specified last* year for: | | *As estimated or *recommended this* year for: | |
|---|---|---|---|---|
| **Quantity** | 2021 | 2022 | 2022 | 2023 |
| *M* (natural mortality rate)** | 0.2, 0.35 | 0.2, 0.35 | 0.2, 0.35 | 0.2, 0.35 |
| Tier | 3a | 3a | 3a | 3a |
| Projected total (age 1+) biomass (t) | 923,646 | 921,074 | 921,690 | 914,915 |
| Projected Female spawning | 497,556 | 509,208 | 509,672 | 528,725 |
| $B_{100\%}$ | 558,826 | 558,826 | 558,826 | 558,826 |
| $B_{40\%}$ | 223,530 | 223,530 | 223,530 | 223,530 |
| $B_{35\%}$ | 195,589 | 195,589 | 195,589 | 195,589 |
| $F_{OFL}$ | 0.160 | 0.160 | 0.160 | 0.160 |
| $maxF_{ABC}$ | 0.135 | 0.135 | 0.135 | 0.135 |
| $F_{ABC}$ | 0.135 | 0.135 | 0.135 | 0.135 |
| OFL (t) | 90,873 | 94,368 | 94,445 | 97,944 |
| maxABC (t) | 77,349 | 80,323 | 80,389 | 83,389 |
| ABC (t) | 77,349 | 80,323 | 80,389 | 83,389 |
| | As determined *last* year for: | | As determined *this* year for: | |
| **Status** | 2019 | 2020 | 2020 | 2021 |
| Overfishing | no | n/a | no | n/a |
| Overfished | n/a | no | n/a | No |
| Approaching overfished | n/a | no | n/a | No |

*Projections are based on estimated catches of 8,698 t for 2021, 9,272 t for 2022, and 8,806 t for 2023.
**Natural mortality rate is 0.2 for females, 0.35 for males.

The tests for evaluating these three statements on status determination require examining the official total catch from the most recent complete year and the current model projections of spawning biomass relative to $B_{35\%}$ for 2021 and 2023. The official total catch for 2020 is 10,681 t, which is less than the 2020 OFL of 84,057 t; therefore, the stock is not being subjected to overfishing. The estimates of spawning biomass for 2021 and 2023 from the current year (2021) projection model are 497,740 t and 528,725 t, respectively. Both estimates are well above the estimate of $B_{35\%}$ at 195,589 t and, therefore, the stock is not currently overfished nor approaching an overfished condition.

*Fishery Trends*

Updated catch data (t) for Arrowtooth flounder in the Bering Sea and Aleutian Islands as of October 30, 2021 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org) are summarized in the following table:

| Year | Bering Sea | Aleutian Islands | Total | ABC | TAC |
|---|---|---|---|---|---|
| 2020 | 8,402 | 2,278 | 10,681 | 71,618 | 10,000 |
| 2021 | 6,267 | 1,804 | 8,070 | 77,349 | 15,000 |

Catch of Arrowtooth flounder decreased in all areas in 2021 compared to 2020 but remains within the range of the time series. About 49% of the catch was in the Arrowtooth and Kamchatka flounder fishery, with 4% in the pollock fishery, 6% in the rockfish fisheries, and the remainder mainly in the yellowfin sole and flathead sole fisheries. Currently, "off year" assessments are required to present a catch to biomass ratio, which is calculated as the catch divided by the total age 1+ biomass from the assessment model and 2021 total biomass from the projection model (Shotwell et al. 2020). The catch to biomass ratio for 1991-2021 has ranged from 0.008 in 2017 to 0.037 in 1991 (Table 6.1, Figure 6.1). The Arrowtooth flounder catch/biomass ratio has been steadily decreasing since 2012 (Figure 6.1). The catch to biomass ratio in 2021 was 0.009, and was 0.012 in 2020.

*Survey Trends*

The Alaska Fisheries Science Center (AFSC) eastern Bering Sea (EBS) bottom trawl shelf survey was conducted in 2021. The EBS Arrowtooth flounder biomass estimate was 459,660 (t) for 2021, which was 21% lower than the 2019 survey, but at the long term average for the time series (Figure 6.2). The AFSC longline survey was also conducted in 2021 and relative population number (RPN) estimates are available for Arrowtooth flounder and Kamchatka flounder combined in the Bering Sea and Aleutian Island areas. RPNs for Arrowtooth flounder increased by 79% since the 2020 survey and are now just below the long-term average for the time series (Figure 6.3). Finally, the International Pacific Halibut Commission (IPHC) survey was conducted in 2021 and RPN estimates are available for Arrowtooth flounder in the Bering Sea and Aleutian Island areas. RPNs for Arrowtooth flounder decreased by 52% from last year in the Aleutian Islands and by 51% in the Bering Sea. Both areas are well below the long-term average for the time series (Figure 6.4).

## Summaries for Plan Team

| Species | Year | Biomass[1] | OFL | ABC | TAC | Catch[2] |
|---|---|---|---|---|---|---|
| Arrowtooth Flounder | 2020 | 934,008 | 84,057 | 71,618 | 10,000 | 10,680 |
| | 2021 | 923,646 | 90,873 | 77,349 | 15,000 | 8,070 |
| | 2022 | 921,690 | 94,445 | 80,389 | n/a | n/a |
| | 2023 | 914,915 | 97,944 | 83,389 | n/a | n/a |

[1]Total biomass (ages 1+) from the age-structured model

[2]Current as of October 30, 2021. Source: NMFS Alaska Regional Office Catch Accounting System via the AKFIN database (http://www.akfin.org).

## Responses to SSC and Plan Team Comments on Assessments in General

The following group of comments are the 2021 SSC guidance regarding the risk tables:

- *The SSC concluded that the risk table framework is working well. The tables have expanded communication among assessment authors and between assessment authors and*

*ecosystem/process researchers. The framework is intended to provide a clear and transparent basis for communicating assessment-related and stock condition concerns that are not directly captured in model-based uncertainty, the tier system, or harvest control rules.*

- *The SSC recommended no changes to the language in the Risk Table template.*
- *The SSC recognizes that within the context of the risk tables, "risk" is the risk of the ABC exceeding the true (but unknown) OFL. The risk tables are intended to inform the process of adjusting the ABC from the maximum permissible when needed. Recommendations of an ABC reduction from the maximum permissible requires justification. The risk tables provide an avenue for articulating that justification.*
- *The SSC recommends that consideration for reductions from maxABC be based on current year information unless relevant risk factors for a stock continue to be present from previous years.*
- *The SSC recommends that for stocks managed in Tiers 1-3, that risk tables are produced for all full assessments of groundfish (and perhaps crab) stocks and stock complexes in the fishery. Risk tables can be produced in other years at the discretion of the lead author if there have been notable changes to previous conditions.*
- *The SSC recommends that Risk Tables should not be mandatory for other Tiers; however, stock assessments must include compelling rationale for why a Risk Table would not be informative.*
- *For stock complexes, the SSC recommends that the decision concerning which species (or multiple species) to focus on be up to the author.*
- *The SSC recommended maintaining the status quo, where authors are encouraged (but not required) to provide a recommendation on a reduction from maxABC, if warranted, and the Plan Teams and SSC would then evaluate and modify the reductions (if needed) based on the information available for the stock.*
- *Risk scores should be specific to a given stock or stock complex. While comparison across species (e.g., within a tier, with similar life histories) or stocks is useful for consistency, the SSC does not support trying to prescribe a common reduction from the maximum permissible ABC for a given risk score across species or stocks because the processes underlying the score may differ among species and stocks. The SSC recommends that considerations of reductions in ABCs below the maximum permissible continue to be made on a case-by-case basis with justification based on risk scoring. The risk table rankings include qualitative information that requires a certain amount of subjective but well-informed interpretation of the available data by the author(s), the Plan Teams and the SSC, and as such, the SSC feels that blanket comparisons across species or stocks for the purpose of explicitly defining reductions in ABC below the maximum permissible are not prudent.*
- *The SSC encourages the inclusion of LK/TK/S as a source of knowledge about the condition of the stock, a shift in the spatial or temporal distribution of the resource, or changes in the size or condition of species in the fishery.*
- *The SSC recommends that the fishery/community performance column should focus on information that would inform the biological status of the resource (e.g., an unexplained drop in CPUE that could indicate un-modelled stock decline, or a spatial shift indicating changes in species' range), and not the effects of proposed ABCs on the fishery or communities or bycatch-related considerations. The SSC recognizes that the community impact information is critical for Council decision making and supports efforts to effectively communicate where this information can be accessed.*
- *The SSC appreciates the discussion of avoiding double-counting information, in the assessment/Tier system and risk table, or among columns of the risk table. The SSC agrees that authors should avoid inclusion of stock trends/processes that are incorporated in the assessment or reflected in the Tier when scoring the risk tables. For cases where a process external to the assessment is relevant to two or more risk categories, the SSC recommends that the narrative reflect the interconnected relationships that exist between rankings among risk categories.*

- *The SSC suggests a revision to the category levels: from the existing four to three categories (normal, increased, extreme). The SSC recommends postponing this change until 2022 as many authors have already begun working on risk tables for 2021.*
- *The SSC reiterates that reductions in ABC below the maximum permissible should be applied sparingly and that the tier system should be regarded as the primary basis for establishing the ABC. If they begin to become commonplace, that should warrant further review of the assessment and/or the Tier system.*

We provided a risk table in the last full assessment. Since this is a partial assessment year, we do not provide a risk table as recommended by the SSC.

### Responses to SSC and Plan Team Comments Specific to this Assessment

*"The SSC recommends that the authors check the parameterization for selectivity and the estimated selectivity curves for the shelf survey to verify that the peaks of the domed shape failing to reach a value of 1.0 does not create any unexpected artifacts in the calculations or change the interpretation of catchability or other model results. In addition, the SSC requests the authors bring forward historical information on the rationale used for the selectivity parameterizations used in the assessment."* (SSC, December 2020)

We plan to bring forward historical information on the rationale used for the selectivity parameterizations in the next full assessment to the extent possible given multiple lead authors on this assessment.

## Literature cited

Hollowed, A.B., K. Aydin, K. Blackhart, M. Dorn, D. Hanselman, J. Heifetz, S. Kasperski, S. Lowe, and K. Shotwell. 2016. Discussion paper stock assessment prioritization for the North Pacific Fishery Management Council: Methods and Scenarios. Report to NPFMC Groundfish Plan Teams. September 2016. https://www.npfmc.org/wp-content/PDFdocuments/meetings/AFSC-HQ_Discussion_Paper.pdf.

Methot Jr., Richard D. (editor). 2015. Prioritizing fish stock assessments. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-152, 31 p.

Spies, I., T.K. Wilderbuer, D.G. Nichol, J. Hoff, and W. Palsson. 2018. Assessment of the Arrowtooth flounder stock in the Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands. North Pacific Fishery Mngt. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. 100 p.

Shotwell, S.K., I. Spies, L. Brit, M. Bryan, D.H. Hanselman, D.G. Nichol, J. Hoff, W. Palsson, T.K. Wilderbuer, and S. Zador. 2020. Assessment of the Arrowtooth flounder stock in the Bering Sea and Aleutian Islands. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands. North Pacific Fishery Mngt. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. 88 p.

Table 6.1 Biomass estimates for Arrowtooth flounder from the 2020 full assessment model, except for 2021, which was generated by the single species projection model. *Catch data is from the NMFS AKRO BLEND/Catch Accounting System, except for 2021 which is an estimate based on the catch as of October 30, 2021 extrapolated to Dec. 31, 2021 based on average catches from 2016-2020.

| Year | Biomass | Catch* | Catch/Biomass Ratio |
|---|---|---|---|
| 1991 | 479,084 | 17,559 | 0.037 |
| 1992 | 525,456 | 10,707 | 0.020 |
| 1993 | 567,589 | 8,369 | 0.015 |
| 1994 | 600,109 | 12,904 | 0.022 |
| 1995 | 615,617 | 8,356 | 0.014 |
| 1996 | 630,445 | 13,189 | 0.021 |
| 1997 | 637,093 | 9,422 | 0.015 |
| 1998 | 648,081 | 13,713 | 0.021 |
| 1999 | 659,884 | 10,240 | 0.016 |
| 2000 | 681,479 | 11,907 | 0.017 |
| 2001 | 708,082 | 12,652 | 0.018 |
| 2002 | 739,703 | 10,670 | 0.014 |
| 2003 | 776,941 | 11,928 | 0.015 |
| 2004 | 814,846 | 16,367 | 0.020 |
| 2005 | 845,578 | 12,819 | 0.015 |
| 2006 | 877,315 | 12,098 | 0.014 |
| 2007 | 904,713 | 10,724 | 0.012 |
| 2008 | 926,914 | 14,104 | 0.015 |
| 2009 | 937,393 | 17,342 | 0.019 |
| 2010 | 935,113 | 17,847 | 0.019 |
| 2011 | 923,956 | 20,141 | 0.022 |
| 2012 | 904,316 | 22,325 | 0.025 |
| 2013 | 881,158 | 20,537 | 0.023 |
| 2014 | 861,831 | 19,110 | 0.022 |
| 2015 | 846,526 | 11,269 | 0.013 |
| 2016 | 843,500 | 11,099 | 0.013 |
| 2017 | 856,131 | 6,519 | 0.008 |
| 2018 | 882,125 | 7,001 | 0.008 |
| 2019 | 911,700 | 10,121 | 0.011 |
| 2020 | 927,610 | 10,681 | 0.012 |
| 2021 | 923,851 | 8,698 | 0.009 |

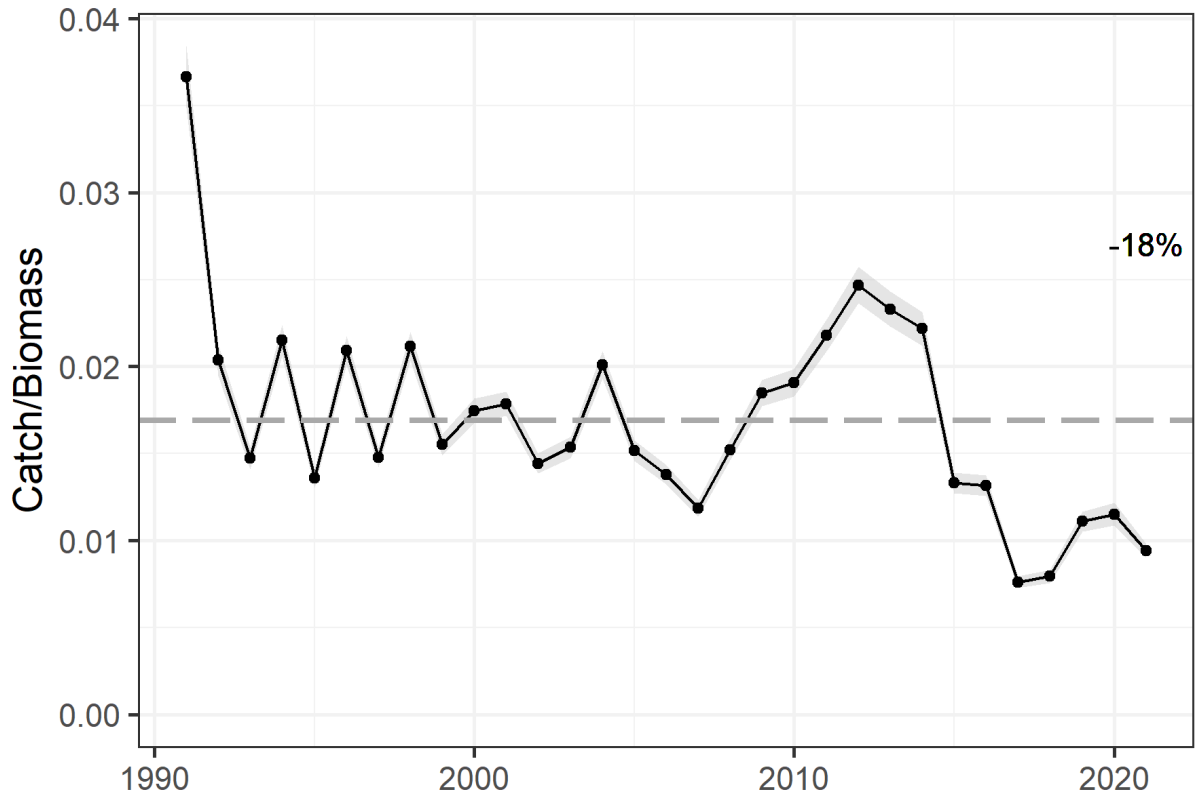


Figure 6.1 Catch to biomass ratio for BSAI Arrowtooth flounder from 1991-2021. Value for 2021 was based on projected estimates.

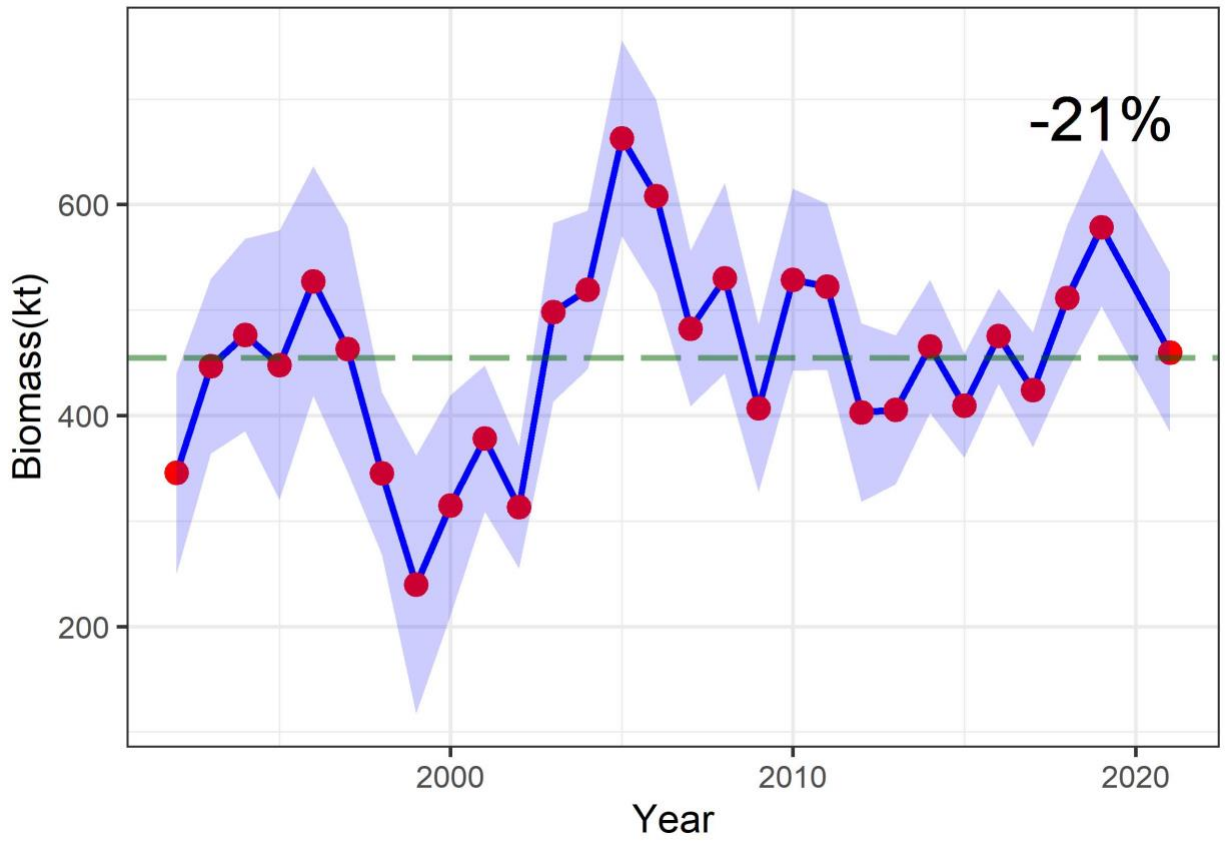


Figure 6.2 Biomass estimates of Arrowtooth flounder from the AFSC Eastern Bering Sea bottom trawl survey, 1992-2021, with 95% confidence intervals.

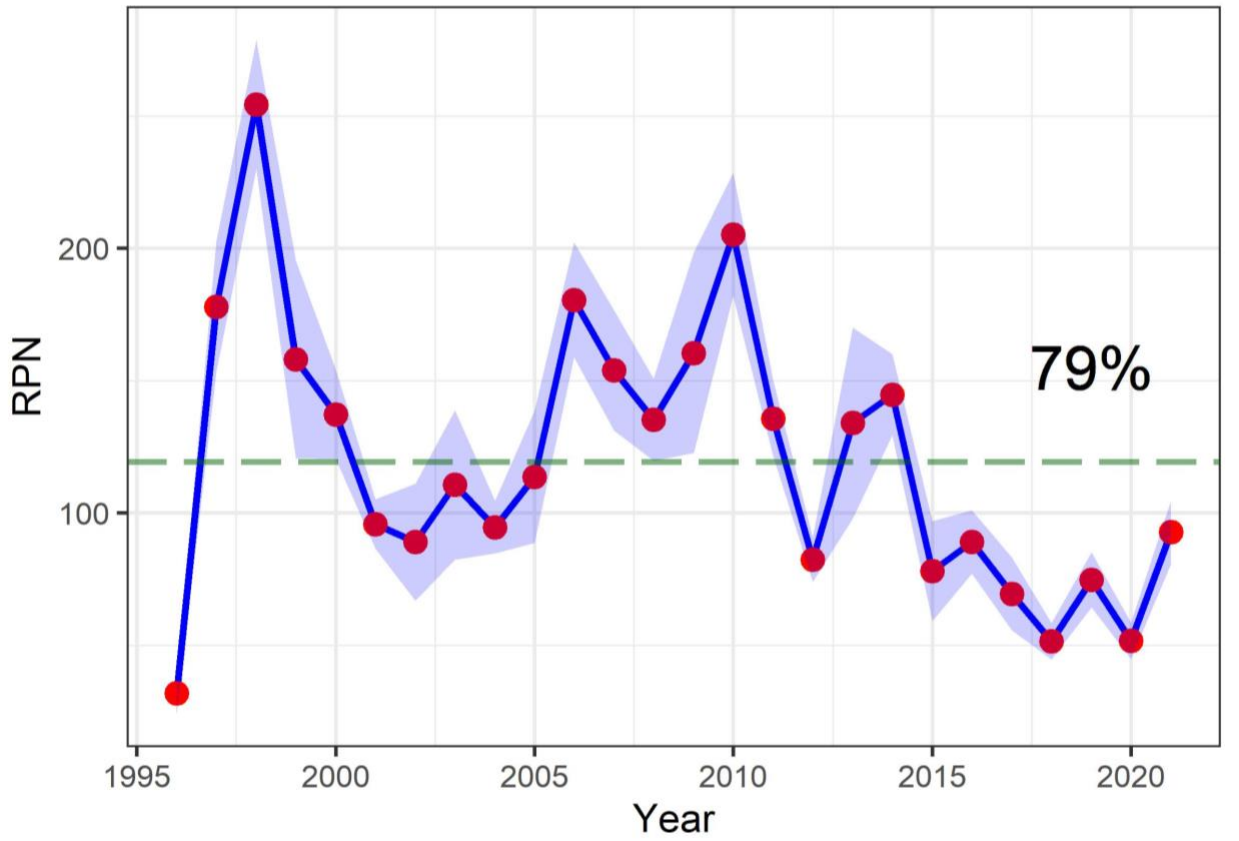


Figure 6.3. Relative population numbers (RPN) of Arrowtooth and Kamchatka flounder combined from the Alaska Fisheries Science Center (AFSC) longline survey in the Bering Sea and Aleutian Islands.

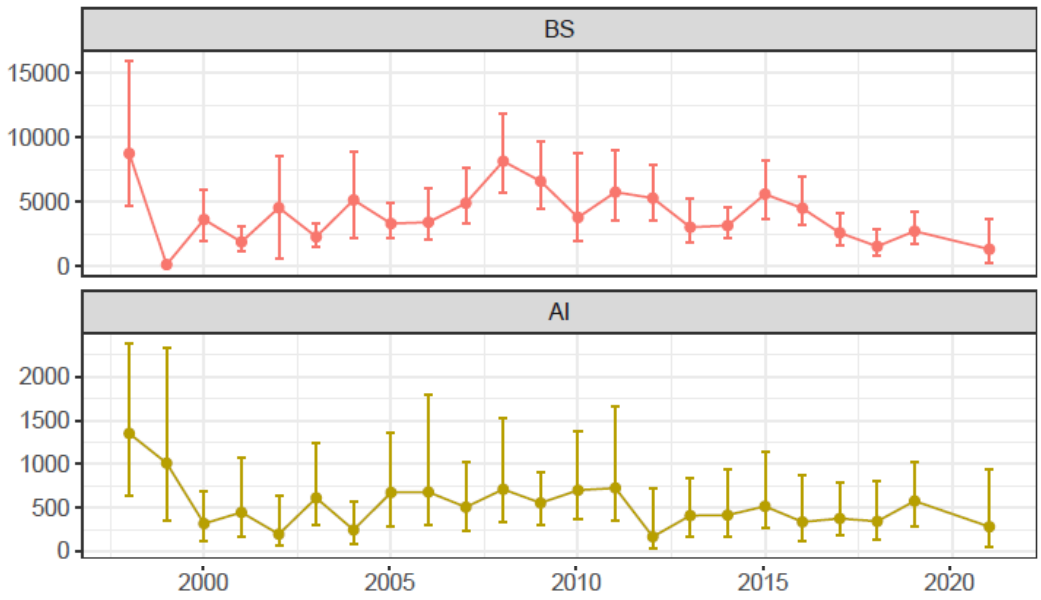


Figure 6.4. Relative population numbers (RPN) of Arrowtooth flounder from the International Pacific Halibut Commission (IPHC) longline survey in the Bering Sea (BS) and Aleutian Islands (AI).